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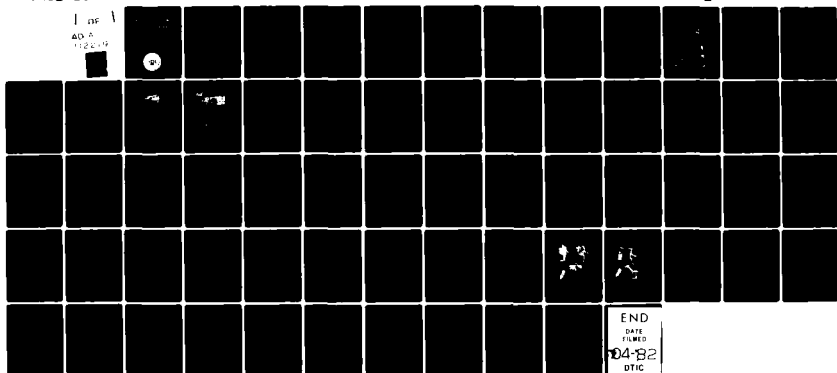
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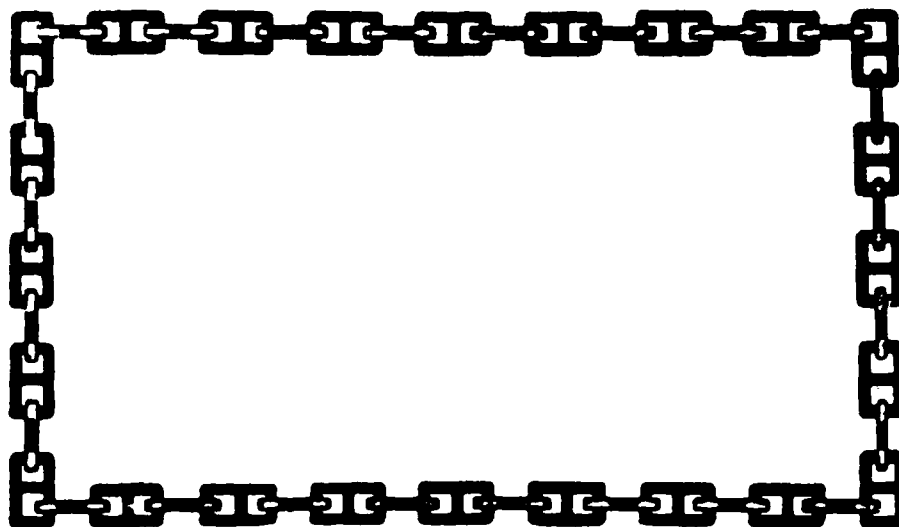
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DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
PANAMA CITY, FLORIDA 32407

NAVY EXPERIMENTAL DIVING UNIT

REPORT NO. 1-81

EVALUATION OF COLOR UNDERWATER TV
AND TOPSIDE EQUIPMENT

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JANUARY 1981

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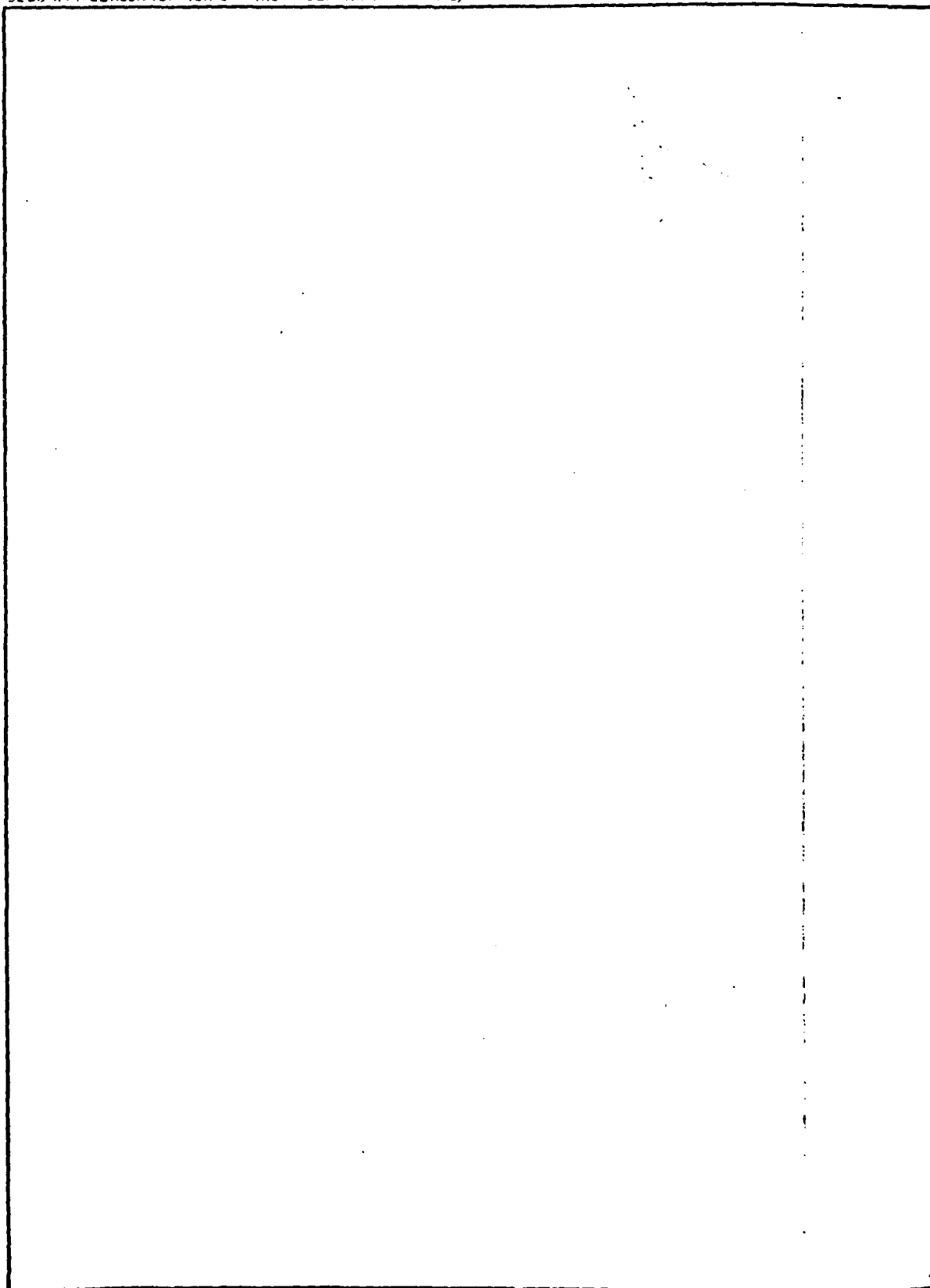
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ABSTRACT

Five commercially available underwater, hand-held, color cameras and TV systems were tested for use by divers to help perform in-water hull and waterfront inspections. The camera systems are evaluated and rated by how well they fulfill specific critical parameters related to this application.

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INTRODUCTION

The purpose of this evaluation is to explore the feasibility of a diver hand-held underwater color camera and TV system to improve the quality and efficiency of in-water hull and waterfront maintenance, repair, and inspection. Four test conditions were used for the feasibility evaluation with an intent to determine whether the tested commercially available underwater color TV systems meet the general requirements of NAVSEAINST 9597.1 to permit Fleet utilization and candidacy for Authorized for Navy Use (ANU) status. The tests, entitled NEDU Test Plan 80-4 "Color Underwater TV and Topside Equipment," were conducted by personnel from the Supervisor of Salvage, Naval Sea Systems Command, West Coast Representative Group, Treasure Island, California and the Navy Experimental Diving Unit, Panama City, Florida. This report correlates the test results and presents evaluation comparisons on the Aqua-Air, ISE Gulf, Kinergetics, Rebikoff, and Sub-Sea units. The evaluation presentation includes:

1. Assessment of the capability of the various components to provide their intended function of simultaneous television monitoring and audio/video recording capabilities for in-water inspection of hulls and waterfront facilities.
2. Determination of the clarity and appropriateness of the technical documentation provided by the manufacturers of the various test articles.
3. Assessment of the safety and human engineering characteristics of the TV system components.

SYSTEM DESCRIPTIONS

Five diver hand-held underwater color cameras and associated TV system equipment were tested. The manufacturers and model number of the systems tested are shown in Table 1.

Table 1. LIST OF MANUFACTURERS

<u>Manufacturer</u>	<u>Model No.</u>
Aqua-Air Industries Inc. 221 Back Drive Post Office Drawer 719 Harvey, LA 70059	500 PVS Color TV System
ISE Gulf Inc. 3915 B Dacoma Street Houstin, TX 77092	Underwater Color Television System and Interfacing Control Unit
Kinergetics, Inc. 6029 Reseda Boulevard Tarzana, CA 91356	Color Observer I COB-I
Rebikoff Underwater Products, Inc. 3060 S.W. 4th Avenue Ft. Lauderdale, FL 33315	DR 632 Dirty Water Industrial Color TV System
Sub-Sea Systems, Inc. 753 West Washington Avenue Escondido, CA 92025	Sea Bee II Underwater Tele- vision System

Each system was leased from its respective manufacturer and freighted to Treasure Island, California, for checkout and later testing. Refer to Appendix A for technical documentation for each system. A brief system description of each unit follows.

Aqua-Air Model 500 PVS Color TV System

This system is packaged in two fiberglass integrated shipping cases, one containing the control console with its built-in color monitor and video cassette recorder (VCR), and another which contained the camera, snooperette light and umbilical. The console case also carried a 110 VAC power cord, 120-minute Panasonic video tape, operating instructions folder, VCR operator manual, and a boxed telex headset. The single snooperette light mounts directly on the top front of the cylindrical aluminum camera housing with its central underside diver grip. The

control console also features audio communications, with a built-in radio or via use of an external helium voice processor, in addition to the camera controls. The communications package was not part of the evaluation. Refer to Figure 1 for pictorials of the hand-held camera unit and of the umbilical.

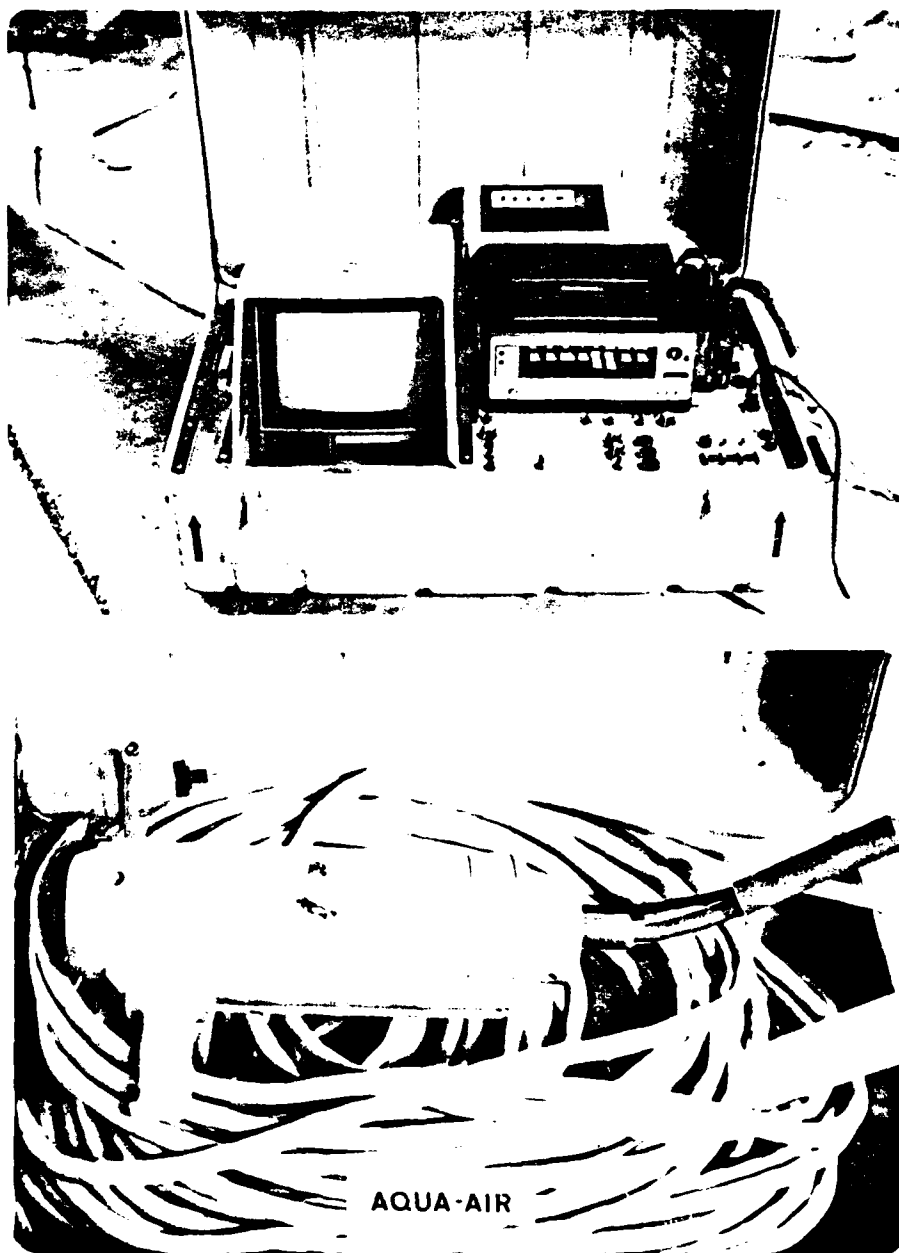


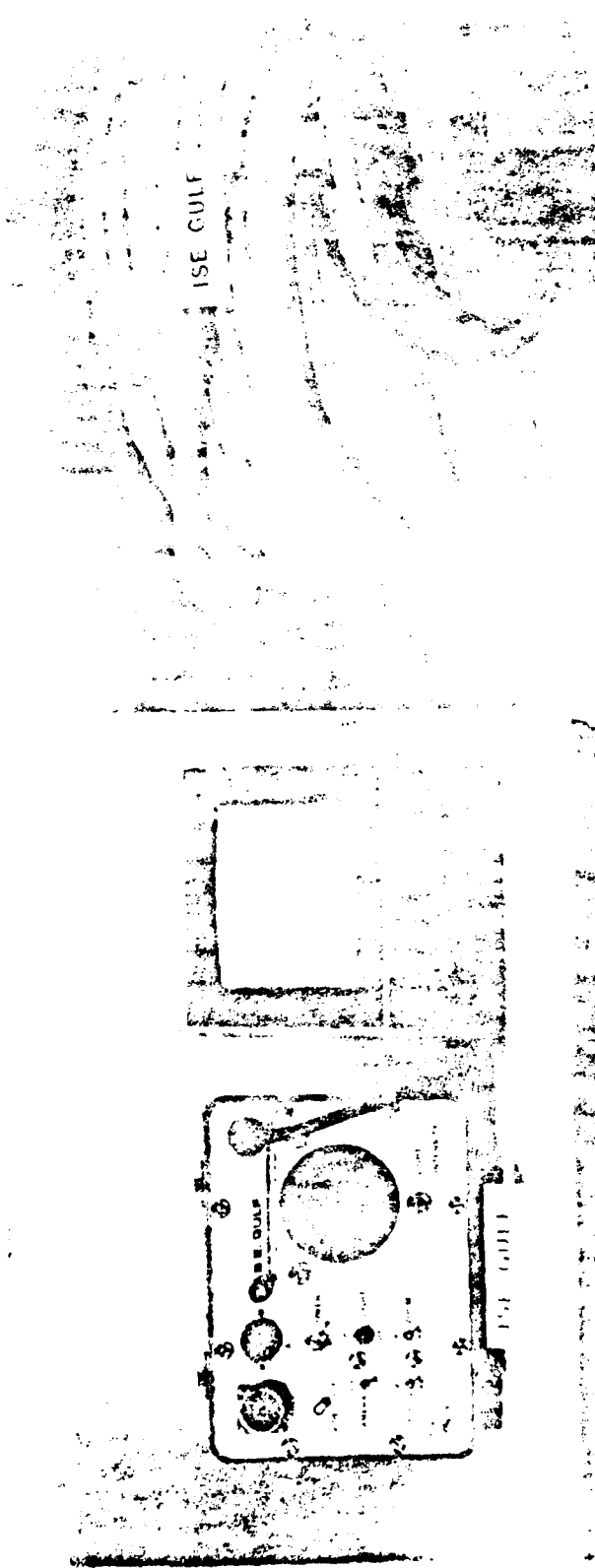
Figure 1. AQUA-AIR MODEL 500 PVS COLOR TV SYSTEM

ISE Gulf Underwater Color TV System and Interfacing Control Unit

The ISE Gulf system arrived in two cardboard boxes, one each for the separate color monitor and control unit, and an aluminum suitcase containing the camera and single attached snooper light, one spare coax cable fitting, console power 110 VAC cable, one console to monitor cable, and a schematic. There is also a 500-foot umbilical with diver communication provision wound on a wooden spool. The single snooper light mounts on the top of the camera's cylindrical nylon housing with its pistol grip mounted on the underside. Both items can be slide adjusted together throughout the housing's length. The control box consists only of camera and light controls. Refer to Figure 2 for pictorials of the control box and monitor, hand-held camera and light unit, and the wound umbilical.

Kinergetics Color Observer I

This system arrived in two large cardboard boxes. One of them contained both an aluminum case which held the VCR, camera with built-in light in a aluminum housing, fuses, one O-ring, camera handle, recorder to console cable, one Allen T-wrench, and a set of instruction books and an accessory box containing the lead battery, JVC remote control unit, antenna, 3-way signal splitter, two antenna leads, single 75 ohm lead and mini earphones. The second large box contained the control console and a small cardboard box which held a blue nylon bag. Inside this bag were stored the 250-foot umbilical, 12 VDC power cord, 110 VAC main power cable, telex headset, and an external speaker. The control console has a built-in 8 inch color monitor and options for diver communications and 12 VDC operation besides the usual camera and light controls. The diver hand-held camera unit has a single incandescent lamp mounted within the housing and is intensity variable. Refer to Figure 3 for a pictorial view of the Kinergetics Color Observer I System.

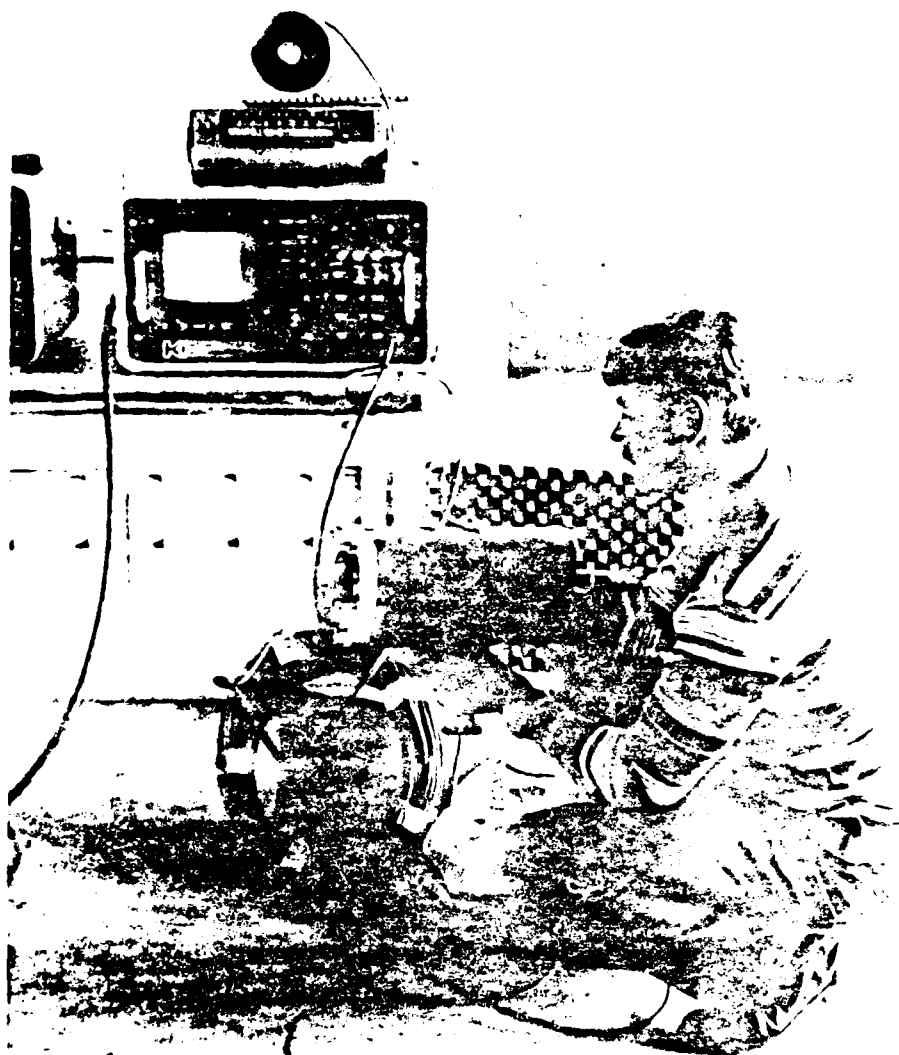


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Figure 2. ISE GULF UNDERWATER COLOR TELEVISION SYSTEM AND INTERFACING CONTROL UNIT



KINERGETICS

Figure 3. KINERGETICS COLOR OBSERVER I

Rebikoff DR632 Dirty Water Industrial Color TV System

The Rebikoff system arrived in a fiberglass case and cardboard box. The cardboard box housed a control unit which is actually an isolation transformer with two on/off switches and two dimmer controls. No top-side monitor is provided, therefore a government furnished monitor was utilized. The case contained a bag of spare connectors, operator manual, 168 feet of umbilical, two 110 VAC lights (250 watt and 500 watt), standoff, DR632 color camera in its housing, and a diver monitor, bicycle pump, and a pressure gauge in a black pouch. There are two lights mounted to the camera housing; a 250-watt top-front light, and an adjustable 500-watt lower front extended mount light. The diver hand-grip is located towards the lower front of the camera housing. And, a diver viewfinder/monitor is mounted on the rear top to complete the assembly. Refer to Figure 4 for a pictorial view of the Rebikoff system.

Sub-Sea Sea Bee II

Three shipped items made up the Sea Bee II system. The first was a wooden box containing the color camera, single 250 watt incandescent lamp with its reflector mount, pair of telex headphones, camera mounted monitor with a rubber hood, camera body mounting ring, and a camera to viewfinder/monitor whip. The second item was a cardboard box enclosing the control console and the 110 VAC power cable. Lastly, the 100 meter (approximately 300 feet) umbilical was shipped wound on a wooden spool. The single light is forward-underside mounted to the cylindrical aluminum camera housing, while the diver viewfinder/monitor is back-topside clamped. A 9 inch color monitor is built in to the control console which features a data entry option along with diver communications, camera and light controls. The diver communication option was not evaluated. The data entry was found to be a convenient asset but was not a deciding factor in the evaluation. Refer to Figure 5 for a pictorial of the Sub-Sea Sea Bee II system.

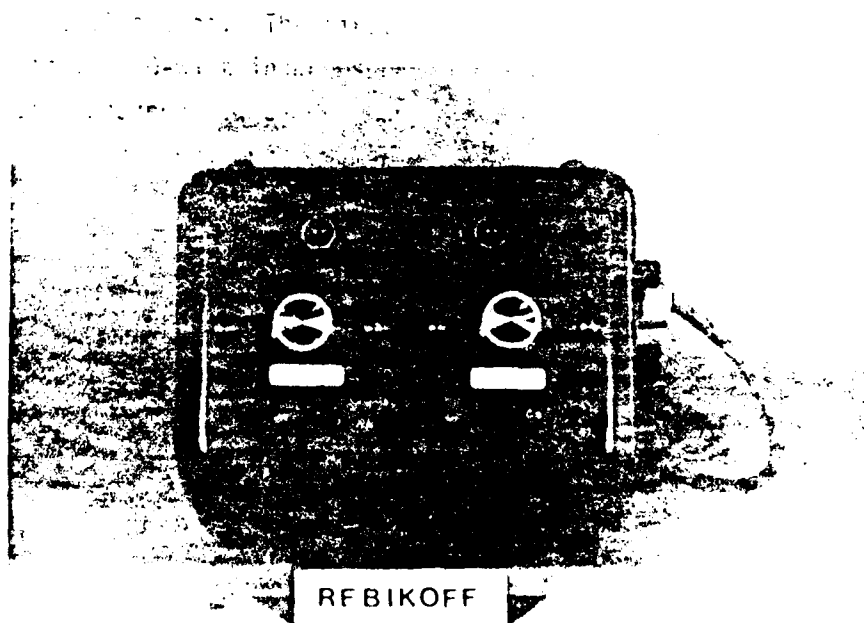
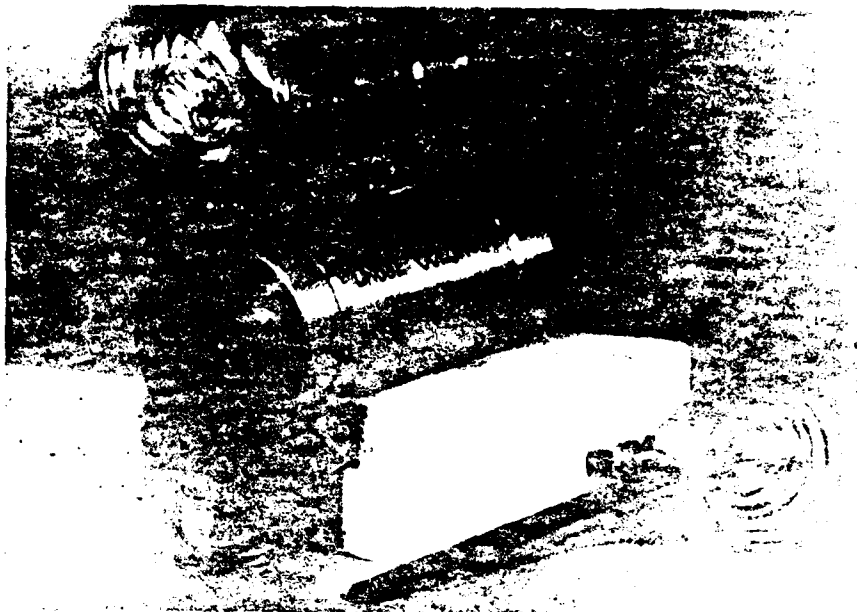


Figure 4. REBIKOFF DR632 DIRTY WATER INDUSTRIAL COLOR TV SYSTEM



Figure 5. SUB-SEA SEA BEE II SYSTEM

TARGET DESCRIPTIONS

Each of the five test articles was exercised to inspect the test targets listed below under the following conditions:

1. Daylight - low turbidity. This test was conducted at the Treasure Island test pool.
2. Daylight - high turbidity. This test was performed at the harbor waters of Subic Bay, Philippines.
3. Night - low turbidity. This test was conducted at the Treasure Island test pool.
4. Night - high turbidity. This test was performed at the harbor waters off Treasure Island.

The test targets were:

1. Zinc plates
2. Sea suction opening screen
3. Keel block area
4. Propeller, rope guards, fairwaters and dunce caps
5. Rudder
6. Pool target

Items 1, 4 and 5 of the test targets were handled at Treasure Island and Subic Bay by inspections of a Navy tugboat at night and a 1053 class fast frigate in daylight, respectively. The primary point of comparison between the five test systems on the Treasure Island test was on the tug's zinc plates. The following points on the Subic Bay test were observed:

- a. Rudder post
- b. Fairwater around stern tube
- c. Strut
- d. Propeller hub
- e. Sea suction
- f. Keel block area on skeg
- g. One blade of propeller and prairie masker holes

Items 2, 3, 4, and 5 of the test targets were covered in the Subic Bay test, while item 6 was handled via the Treasure Island pool day and night tests. The specially constructed target used in the pool tests was

simply an assorted array of color squares mounted facing the test camera's view axis with one-foot distance increment adjustments. Focus, zoom, light intensity, and peripheral angle factors were observed.

RESULTS AND DISCUSSIONS

Test results were correlated and organized which lead to evaluation comparisons on the five tested commercially available TV systems.

Ability to Perform Intended Function

The primary function of all of the tested units is to provide simultaneous television monitoring and both video and audio recording capabilities for in-water inspections of hulls and waterfront facilities. All units provided adequate color rendition, but only two, the Rebikoff and the Sub-Sea, had diver carried monitors which allowed the diver to view the same scene as topside. This became a factor in obtaining quality video results. Aqua-Air, Kinergetics, and the Sub-Sea systems all had good-quality consoles with built-in color monitors. The Aqua-Air system featured a built-in color bar setup which essentially only benefits the built-in monitor's response. The Sub-Sea system featured a built-in data entry system. The ability to adjust light intensity and light placement itself were factors in obtaining good-quality video responses.

Ratings between the five units with respect to intended functional performance are listed below. Rating scale is from 1 to 5 with numbers 1 being the best unit in a specific area of evaluation and number 5 being the worst

<u>Unit</u>	<u>Rating</u>
Aqua-Air	4
ISE Gulf	5
Kinergetics	3
Rebikoff	2
Sub-Sea	1

Cost

Table 2 provides a comparative component, system and lease cost breakdown between the tested units, at that time.

Manufacturer	TV Camera	Control Unit & Monitor	Light	Umbilical	System Cost	Lease (30 days incl. freight)
Aqua-Air	\$ 4,300	\$8,000	\$300	250' \$495.00	\$12,500.00	\$3,827
ISE Gulf	\$ 4,000	\$2,400	\$600	500' \$1,900	\$ 8,900.00	\$2,000
Kinergetics	\$ 4,000	\$5,500, diver comm. \$500, VDC operation \$1,200	incl. w/ camera cost	250' \$130.00	\$ 9,989.00	\$1,600
Rebikoff	\$14,933 less 15%	no monitor \$998	\$925 less 15%	164' \$833.00	\$15,035.00	\$2,936
Sub-Sea	\$ 4,600	\$7,750 data entry \$1,200	\$625	328' \$1,000	\$12,500.00	\$3,185

Table 2. COMPARATIVE COST BREAKDOWN

Portability

In this category, the size and weight of the system in its packaged condition are considered for handling by two people.

Aqua-Air - Two large thermo plastic cases are used to ship this system. One measured 18" x 36" x 24" and weighed 150 lbs; while the other measured 18" x 36" x 24" and weighed 140 lbs. The actual breakdown was one box with the console, control panel and recorder and the other with the camera and umbilical.

ISE Gulf - The system arrived in two large containers. One measured 26" x 19" x 9.5" and weighed 35 lbs, while the other measured 22" x 22" x 13" and weighed 81 lbs. The actual breakdown consists of cardboard boxes for both the monitor and control box and of an aluminum suitcase for the camera and associated components. The umbilical is wound on a large wooden spool.

Kinergetics - The Kinergetics system was shipped in two containers. One measured 26" x 19" x 9½" (51.5 lbs), and the other 22" x 22" x 13" (65 lbs). The actual breakdown was the aluminum case with VCR and camera, accessory box, control console, and a blue nylon bag with the umbilical.

Rebikoff - The complete system consists of one cardboard box housing the isolation transformer/dimmer control box (42 lbs), and an impact resistant plastic case for the camera, umbilical and associated equipment (67 lbs). The cardboard box dimensions were 12" x 12" x 12" and the plastic case 32" x 18" x 10".

Sub-Sea - The complete system minus the umbilical arrived in one container 24.5" x 14" x 14" and weighed 46 lbs. Inside there is a cardboard box for the control console and a wooden box with the camera and associated equipment. The umbilical is mounted on a wooden spool.

The comparative portability ratings of the five tested TV systems are as follows:

<u>Unit</u>	<u>Rating</u>
Aqua-Air	1
ISE Gulf	5
Kinergetics	2
Rebikoff	3
Sub-Sea	4

NOTE

Sub-Sea and ISE received low marks because of cable storage.

Support Required

This evaluative criterion refers to the ease of system setup and to whether an umbilical tender in water is recommended.

Aqua-Air - Although the camera is heavy, the system is easily set up (within 8 minutes) as there are only two main components, the control console and camera unit. Two men are required to handle the large, heavy console. The cable is heavy in the water; therefore, an umbilical tender is recommended.

ISE Gulf - One person can setup this system (20 minutes) as the control box is small. The umbilical is bulky and heavy so difficulty will be experienced here. Again, as with the Aqua-Air case, an umbilical tender is recommended.

Kinergetics - Setup is easy and can be accomplished in 15 minutes by one person. The umbilical is hard to handle in that it is difficult to coil and keep from bending, but once in the water, no tender is needed.

Rebikoff - One-man setup is easy and can be done in about 21 minutes. The isolation transformer/dimmer box is small but heavy. The umbilical is light and easily connected, yet caution is needed in hookup because of use of the same kind of connectors. Due to the fact that only one person is needed for system setup and no umbilical tender, the Rebikoff system has a good support rating.

Sub-Sea - System setup can be accomplished in 12 minutes. Only one person is needed. The umbilical is bulky and heavy, making it difficult to work with. In the water, an umbilical tender is recommended.

The ratings of the five units per support required are shown below.

<u>Unit</u>	<u>Rating</u>
Aqua-Air	5
ISE Gulf	4
Kinergetics	2
Rebikoff	1
Sub-Sea	3

Problem Areas

This evaluation pertains to the occurrence of any failures during testings and covers only a short period of time.

Aqua-Air - The Aqua-Air unit had its camera light burnout during the first night dive. After replacement, it did not recur throughout testing. Also, at one time the camera end connector was discovered to be loose, thus making camera flooding possible, however, no flooding occurred. No umbilical caps were provided which should be included for protection. External connectors are pinned to prevent improper mating and cannot be inserted into the wrong receptacles.

ISE Gulf - The right angle (90 degree) camera connector is one problem; broken wires occurred during testing which caused abortion during the night, low turbidity test. The potting also separated from the umbilical at the diver's end. The external connectors are pinned to prevent improper mating and misalignment and cannot be inserted into the wrong receptacles. However, the umbilical at the diver's end is not similarly protected.

Kinergetics - The only negative aspect of this system was the umbilical's susceptibility to damage. It was lightweight but hard to handle due to it's susceptibility to kink and bend. It also had no connector covers. The external connectors are pinned to prevent improper mating and misalignment, but on the recorder they can be inserted into the wrong receptacles. The installed light is considered inadequate beyond 4 to 5 feet.

Rebikoff - The umbilical is judged to be a reliability problem. The light cable (umbilical) hangs up and in one case severed, causing camera failure during the daylight high turbidity test. It needs an outer protective jacket to prevent this from happening. All of the cable's connectors are the same and thus, easily misconnected. A 110 VAC line can be connected to "video out," a potential hazard to equipment but not to personnel. The knobs on the control box are easy to damage, and the control box closure snap device separated on one side.

Sub Sea - During the night high turbidity test, the control console's power module failed due to the shorting of two transistors on the console case. A spare module was obtained, fuses replaced and reverse mounted for diode-to-case clearance. The problem never occurred again. On the plus side, the external connectors are pinned to prevent improper mating and misalignment, except on the camera, and cannot be inserted into the wrong receptacles. The umbilical-to-camera connection is bolted on, making a secure joint.

The problem area ratings of the five tested systems are as follows:

<u>Unit</u>	<u>Rating</u>
Aqua-Air	2
ISE Gulf	4
Kinergetics	1
Rebikoff	5
Sub-Sea	3

Operational Aspects

Information pertaining to this criteria was obtained through diver interviews and the human factors assessment forms.

Aqua-Air - The camera's light angle adjustment is of the screw locking shaft style, this prevents the diver from making adjustments while in the water. In reference to the console controls, grouping is good along with consistency of movement. Location of primary controls is up front. Labels have good orientation and location, are clearly legible and visible, and are durable.

ISE Gulf - The umbilical connects near the top of the control box and tends to tip it over. Also, the power on/off switch is marked vertically but works horizontally. Rotation of the toggle switch would easily remedy this. Otherwise, the consistency, up front location and grouping of controls are acceptable. Visibility and legibility of the labels are clear, and durability seems evident.

Kinergetics - No problems were encountered. The console's controls have good consistency of movement and grouping, while primary controls are located at the front of the control panel. Label orientation and location are good and are visible, legible and durable.

Rebikoff - The camera controls are not satisfactory. Better identification and protection are needed. The dimmer controls are plastic and easy to break. Grouping is not arranged well with the top and side location of the primary controls. Labels are oriented inconsistently with poor ratings for visibility, legibility and durability.

Sub-Sea - Controls have good consistency in movement, grouping and up-front locations. Label orientation and location are good along with durability. Visibility and legibility are rated as satisfactory.

The operational aspects ratings among the five tested systems are shown below.

<u>Unit</u>	<u>Rating</u>
Aqua-Air	3
ISE Gulf	4
Kinergetics	2
Rebikoff	5
Sub-Sea	1

Handling Aspects

Information through diver interviews and the human factors assessment forms provided the following points concerning in-water camera handling.

Aqua-Air - The camera/light unit is heavy, awkward, and hard to handle in the water. The measured in-air weight was 19 lbs. while the in-water weight was negative 3 lbs.

ISE Gulf - This unit floats causing the front of the camera to turn upward constantly. This point makes it very hard to handle for the diver. A change in handle location was tried with no success. The heavy umbilical also contributed to this problem. The measured in-air weight was 26 lbs while the in-water weight was a positive 1.2 lbs.

Kinergetics - The Kinergetics camera unit is easy to handle and most able to enter small areas. The umbilical, however, is difficult to handle due to kinking. In-air weight was measured to be 18.5 lbs and the in-water weight was negative 1 lb.

Rebikoff - The camera is large and the lights extend too far outward for entering small areas. The measured in-air weight was 27 lbs. while the in-water figure was a negative 3 lbs.

Sub-Sea - The Sub-Sea unit is easy to handle, but the camera/light assembly is heavy in the water. The heavy umbilical also causes diver fatigue. Measured weights are 24 lbs in-air and negative 4.5 lbs in water.

The handling aspect ratings are shown below.

<u>Unit</u>	<u>Rating</u>
Aqua-Air	4
ISE Gulf	5
Kinergetics	1
Rebikoff	3
Sub-Sea	2

Lens Features and Focal Length

Features discussed are the limiting focus distances, lens data, and remote focus ability.

Aqua-Air - Focus limits are from 2 inches to infinity. The camera lens was a 6 to 1 zoom (17-102 mm) f/2 with automatic iris. The unit has remote focus ability.

ISE Gulf - This camera could not be focused under 24 inches. (Conferring with the manufacturer's representative, it was found that the tested unit did not have a wide angle adapter which would allow focusing to 2 inches.) A 4 to 1 zoom (14-56 mm) at f/1.8 was featured along with remote focus capability.

Kinergetics - Focus distance is from 3 inches to infinity. The camera uses a wide angle 8.5 mm f/1.5 lens and does include remote focus capability.

Rebikoff - This unit was able to focus from 1.5 inches to infinity, uses an f/1.8, 6.5 mm lens, but has no remote focus capability. The manufacturers claim that the image will always be in focus because of its use of a Rebikoff-Ivanoff lens was verified during testing. The Rebikoff's low focal length of 6.5 mm caused the camera to see part of the inside of its housing with a fisheye view effect.

Sub-Sea - Focusing is from 2 inches to infinity. The camera uses a 12.5 mm, f/1.5 lens and has remote focus capability.

In terms of comparative ratings, all of the units had the same focus capability, except for the ISE Gulf unit, so ratings were not assigned. The zoom feature of the ISE Gulf system was not a significant advantage. All lenses were wide angle, ranging from the Rebikoff's 6.5 mm to the ISE Gulf's 14 mm.

Camera Ability to Enter Small Areas

Diver interviews and human factors assessment forms led to the following conclusions concerning the cameras ability to enter small areas (24 inch diameter openings).

Aqua-Air - The camera's heavy weight is a deterrent (awkward and hard to handle) to entering tight areas, however, its size is not a significant problem. A single top light and bottom grip contribute to its compactness.

ISE Gulf - Disregarding the tendency of the camera to turn vertical due to its positive buoyancy, this unit is compact with a top light and bottom grip.

Kinergetics - This unit has the best ability to enter into tight areas. It is light in weight, and the light is self-contained in the camera housing. The only protrusion is the diver hand grip.

Rebikoff - Because of the light extensions camera bulkiness and heavy weight, closeup inspection into tight areas is difficult. Elimination of the lower light which extends out approximately 2 ft would allow more accessibility. This can be achieved by removing the three mounting bolts allowing the light to slide flusher to the camera.

Sub-Sea - The camera's weight in water, light/reflector size (mounted below the camera), and the diver monitor (mounted above the camera) hinder its ability to enter tight places.

Ratings among the five tested units per ability to enter into confined spaces are given below.

<u>Unit</u>	<u>Rating</u>
Aqua Air	2
ISE Gulf	4
Kinergetics	1
Rebikoff	5
Sub-Sea	3

Illumination Characteristics

This criteria includes lamp power, lamp placement, camera sensitivity, and resistance to washout.

Aqua-Air - This system uses a 12 VDC 100 watt light. The single top-forward mounted light becomes too hot for closeup jobs. A full two minutes are needed for camera warmup. The camera is sensitive to surface light and washout occurs with the light on in clear water. Another item to note is that the console's green adjustment point causes image washout, so a lower level must be used.

ISE Gulf - The ISE Gulf system has a single top-forward snooper light which requires 120 VAC at 500 W. Light sensitivity is poor as washout will occur in any light setting. The light produces hot spots on the top section of the picture and shadows on the bottom.

Kinergetics - This unit has its incandescent lamp contained within the camera housing. The lamp is intensity variable up to only 40 candlepower which is inadequate at times. Automatic light compensation is from 100 to 100,000 lux (10 to 10,000 fc) with no washout tendencies noticed. However, the single lamp location caused hot spots at times.

Rebikoff - The Rebikoff unit has a top-forward 250-watt light and a bottom extending 500-watt light which is intensity variable. Only one light is actually needed, but use of the 500-watt light at high intensity helped keep out shadows and worked very well. The camera's automatic light compensation range is from 10 to 10,000 footcandles. No washout tendencies were noticed.

Sub-Sea - The lower mounted 250-watt lamp with reflector is intensity variable and works very well. No hot spots or washout tendencies were observed. Automatic light compensation is from 10 to 10,000 footcandles.

Ratings among the five tested units with regard to illumination characteristics are shown below.

<u>Unit</u>	<u>Rating</u>
Aqua-Air	5
ISE Gulf	4
Kinergetics	3
Rebikoff	2
Sub-Sea	1

Technical Documentation

Specifications on each of the five units are provided in Appendix A. Remarks on clarity and appropriateness of the technical literature are included below.

Aqua-Air - The only literature that arrived with this system was an operating instructions folder which was clear and concise. It included, besides console and camera setup, audio communication, external helium voice processor, and tape playback instructions.

ISE Gulf - No manual was supplied with this unit, but a three-page data sheet, one-page console schematic, and a single page of umbilical connector data were supplied. The data sheets were thorough, clear and concise. No specific setup procedures were provided with this unit consequently a company representative was summoned to go through the procedures with the test team. Future units will come with a manual according to the manufacturer.

Kinergetics - The Color Observer I operating instructions manual includes initial setup, checkout, normal operation, recorder and monitor instructions besides the system technical specifications. Complete electrical schematics are also provided. The Kinergetics technical documentation is thorough and complete.

Rebikoff - The Rebikoff manual provides caution and safety information, leak test procedures, hand-drawn hookup diagram, operation instructions, and major specifications. The information in the manual pertaining to the DR632 system tested was handwritten as the manual was originally produced for another system. A call to the factory was necessary to obtain complete technical specifications.

Sub-Sea - The hard-cover Sub-Sea 3 ring folder operation and maintenance manual provides a complete description, installation operation, theory of operation and maintenance, and diagrams for the control console, camera power supply and lamps. This complete, well-organized, and concise manual also includes a section on options and reference documents.

Ratings among the five tested systems for technical documentation are given below.

<u>Unit</u>	<u>Rating</u>
Aqua-Air	5
ISE Gulf	3
Kinergetics	2
Rebikoff	4
Sub-Sea	1

Safety Features¹

Recognizing that the approved TV systems will be used as maintenance/salvage tools and for that reason will often be used under less than ideal conditions, i.e. ship of opportunity, adverse weather, etc., each system was evaluated for a specific set of safety parameters. Of concern here, is both the diver and operator safety. Safety features evaluated include:

1. System ruggedness
2. Stability
3. Packaging
4. Cable durability
5. Power requirements
6. Electrical isolation/GFI

Systems were down rated if they required multiple cable connections between components and further down rated if it was possible to make incorrect connections due to poor or inadequate labels or connector similarities. A tabulation of these parameters is given in Table 3.

Aqua-Air - This system stresses connection to a properly grounded 115 VAC supply. It has a GFI built into the control console, and supplies only low voltage D.C. to the diver. Cable connections are kept to a minimum and are a positive, locking type. All cables have strain relief ends. Labeling for hookup and operation is good. The major

¹Units that were furnished without GFI protection were plugged into a portable GFI and this practice could be followed by users anywhere, also all topside units require protection from adverse weather for exposed components, i.e., VCR's, monitors, etc.

SAFETY ITEM	MFR	AQUA-AIR	USE GULF	KINERGETICS	REBIKOFF	SUB-SEA
Electrical Protection	Topside	GFI	None	GFI	Supply Thru Isolation Transformer	Iso. transformer on supply plus threshold CKT breakers T.S. & Diver
	Diver	Low Voltage D.C.	Isolation Transformer	Low Voltage D.C.		
Labeling		Good	Adequate	Good	Unsatisfactory	Excellent
Power Requirements	Camera	12 VDC/6-12 watts 0.5 - 1 amp	12 VDC/6 watts/ 0.5 amp	12 VDC/~7.5 watts ~1.6 amp	12 VDC/7.5 watts/ 1.6 amp	<16 VDC/12 watts max. 0.75 amps constant current
	Light	12 VDC/100 watts 8.3 amp var	120 VAC/500 watts 4 amps (ISC from GND)	30 VDC/~30 watts 1 amp maximum	115 VAC/250 watts and 500 watts	110 VAC/5 amps (maximum)
Control/VCR/ Monitor		115 VAC, 60 HZ 6.5 amp	120 VAC, 60 HZ 5-10 amps	110 VAC, 60 HZ 3 amp maximum or 12 VAC/300 watts	115 VAC, 60 HZ	115 VAC, 60 HZ
Umbilical	Strain Relief	No	Yes but inadequate to protect connectors	No	No	Yes thru reinforced jacket
	Rugged	Yes	Yes	No - kinks, bends	No - fragile, 4 individual cables	Yes
Connecting Wires Between Components		None, single housing	Multiple Leads	Multiple Leads	Multiple Leads	Exceptional
Packaging/Setup		Console heavy 150 lbs. Easy setup	Individual units may cause a hazard	From umbilical storage (cloth bag)	Potential to connect wires to wrong place	Umbilical storage poor. Good setup

Table 3. SYSTEM SAFETY FEATURES

fault of this system is the 150 lbs weight of the control/monitor/VCR package.

ISE Gulf - This system uses an isolation transformer to protect the diver from electrical hazard. There is no GFI or other means to protect the topside operator. Labeling for hookup and operation is adequate, but could be improved. The umbilical is provided with strain relief, however it is inadequate as the camera end connectors are still susceptible to failure.

Kinergetics - The safety features for this system include: GFI for topside operation protection and low voltage D.C. for diver protection. The control unit packaging and setup is acceptable with good labeling. The only fault of the system is the umbilicals susceptibility to kink and bend and the cloth bag for storage.

Rebikoff - The electrical safeguard for this unit is an isolation transformer. This system was down rated because of its unsatisfactory labeling and potential to incorrectly connect umbilical wires. Additionally, the umbilical was made up of four individual cables, married together with tape, which is easily fouled and susceptible to damage and failure.

Sub-Sea - This system uses an isolation transformer in conjunction with threshold circuit breakers for both topside operator diver protection. The labeling on the control unit is excellent and hookup is straightforward. A major failing is the wooden spool which was used for storage of the umbilical. This is heavy, awkward and presents a potential hazard, when handling.

The safety features ratings are shown below.

<u>Unit</u>	<u>Rating</u>
Aqua-Air	2
ISE Gulf	4
Kinergetics	1
Rebikoff	5
Sub-Sea	3

CONCLUSIONS

Comparisons among the five tested underwater color TV systems for diver use in hull and waterfront inspections per single evaluative criteria were presented in the previous section. Twelve factors were discussed. Table 4 summarizes this rating information. It is emphasized that all of the tested units provided adequate color rendition, simultaneous television monitoring topside, and both video and audio recording capability. Only two systems, Rebikoff DR632 and Sub-Sea Sea Bee II, provided diver monitors which were major factors in obtaining quality video results. Any selection of a system is greatly aided by referral to the summary chart. The overall rating given in Table 4 showed the Sub-Sea to be the unit preferred by the test team with all factors considered.

	Ability to Perform Intended Function	System Cost (\$)	Portability	Support Required	Problem Areas	Operational Aspects	Handling Aspects	Lens Features and Focal Length	Camera's Ability to Enter Small Areas	Illumination Characteristics	Technical Documentation	Safety Features	Test Team Overall Preference
Aqua-Air	4	12500	1	5	2	3	4	17-102 mm	2	5	5	2	4
ISE Gulf	5	8900	5	4	4	4	5	14-56 mm	4	4	3	4	5
Kinergetics	3	9989	2	2	1	2	1	8.5 mm	1	3	2	1	2
Rebikoff	2	15035	3	1	5	5	3	6.5 mm	5	2	4	5	3
Sub-Sea	1	12500	4	3	3	1	2	12.5 mm	3	1	1	3	1

Table 4. COMPARATIVE RATINGS SUMMARY CHART

REFERENCES

1. NEDU Test Plan 80-4, "Color Underwater TV and Topside Equipment," dated May 1980.
2. Manufacturers' Tech Manuals.

APPENDIX A
Technical Specifications

AQUA-AIR

TV Camera

Model No.: 500 PVS

No. of Lines Resolution: 250 lines center

Video Output: 1 Vpp 75 ohms

Imaging Device: single 1" vidicon w/tricolor stripe filter

Sensitivity: 15 fc @ f/2

Shade of Grey: 15 steps

Automatic Light Compensation Ratio: 10 to 100 fc

Signal-to-Noise Ratio: 45 db (140 fc @ f/4)

Scanning Standards: 525 lines, 60 fields, 30 frame

% Geometric Distortions: 0.15 overall

Power Requirements: 12 VDC

Camera Lens Data: 6:1 zoom, f=17-102 mm, f/2 w/automatic iris

Method of Focus: remote at console

Camera Size: 18" x 5½" diameter

Camera Weight: 19 lbs in-air, 33 lbs in water

Camera Depth Limit: 1000 fsw

Camera Cost: \$4,300

Control Unit, Monitor and Recorder (Panasonic NV-8400 VCR)

Model No.: not available

Model Size: not available

Resolution (# Lines for Recorder): more than 240

Describe Environmental Protection: weatherproof storage cases

Housing Material: high impact thermo plastic

Power Requirements: 115 VAC 60 Hz + 10% 6.5 amps maximum

Video Response: 1 Vpp, 75 ohms 3.5 megacycles (color)

Controls Provided: volume, vertical hold, color tint, contrast,
red color gain, blue color gain, light level, focus, push-to-
talk, volume.

Describe Communication System: telex headset model 2400

Describe Video Recorder Capabilities: dual rotary heads, FM
azimuth recording, audio dub capability.

Describe Features to Reduce or Simplify Maintenance: modular units, plug-in circuit boards, camera and recorder are off-the-shelf, all power units are plug-in for easy replacement, a special tool is required to open the camera to prevent unauthorized entry.

Cost: \$8,000

Monitor: built-in

Light

Model No.: Birns Snooperette

Type Element Used: 12 VDC 100 W quartz

Light Dimensions: 3" diameter

Watts: 100 W

Candlepower: not available

Power Requirements: 12 VDC

Cost: \$300

Umbilical

Type: 10 conductor urethane jacket

Length: 250 ft to 500 ft

Features: not available

Cost: not available

System Cost

\$12,500

Lease

\$3,827, 30 days including freight

\$125/day plus freight

ISE GULF

TV Camera

Model No.: Panasonic WV3210 with zoom, focus motor

No. of Lines Resolution: 240 horizontal @ center

Video Output: 1 Vpp NTSC composite, 75 ohms

Imaging Device: 2/3" S4104 single vidicon

Sensitivity: 140 fc @ f/1.8

Shade of Grey: not available

Automatic Light Compensation Ratio: not available

Signal-to-Noise Ratio: 43 db (140 fc @ f/2.8)

Scanning Standards: 525 lines 30 fields, 30 frames

% Geometric Distortion: not available

Power Requirements: 12 VDC, 0.5 amp, 6 W

Camera Lens Data: 4:1 ALC zoom; 14-56 mm f/1.8, wide angle adapter
(not on tested camera)

Method of Focus: 6 VDC planetary gear motor, 6 VDC motor zoom

Camera Size: 15" x 6" diameter

Camera Weight: 26 lbs. (bearing-41.2 lbs. (no water)

Camera Depth Limits: 2,000 fsw anodized aluminum, 1,000 fsw nylon
housing (1,000 fsw model tested)

Camera Cost: \$4,000

Control Unit, Monitor and Recorder (Recorder Not Provided)

Model No.: not available

Model Size: not available

Resolution (# Lines for Recorder): not available

Describe Environmental Protection: tongue and groove/rubber gasket

Housing Material: fiberglass with photo etched aluminum panel

Power Requirements: 110 VAC, 60 Hz, 5.10 amp (variac ctrl)

Video Response: 1 Vpp, 75 ohms

Controls Provided: main power on/off; camera power on/off, light
power on/off (built-in circuit breaker); variac (0-110 VAC)
for light intensity; zoom switch (far and near) n.o. focus
switch (far and near) n.o.

Describe Communication System: none except for umbilical provision

Describe Video Recorder Capabilities: not available

Describe Features to Reduce or Simplify Maintenance: (1) camera can be adjusted and repaired at any local Panasonic dealer (one of the cheaper parts of the system); (2) 12 VDC and 6 VDC power supplies are modular and variable and off-the-shelf (2 req'd, both are alike); variac is off-the-shelf.

Cost: \$2,400

Monitor: Panasonic CT-700M 7"

Light

Model No.: 5500 Birns Oceanographic Snooper

Type Element Used: quartz iodide

Light Dimensions: not available

Watts: 500 W

Candlepower: 25,921 center beam (white and blue frosted lens)

Power Requirements: 120 VAC

Cost: \$600 each

Umbilical

Type: wooden spool, yellow BIW urethane jacket, kevlar strands

Length: 500'

Features: diver comm. incl.

Cost: \$1,900

System Cost

Anodized aluminum housing \$9,750

Nylon housing \$8,900

Lease

\$2,000, 30 days including freight

KINERGETICS

TV Camera

Model No.: Color Observer I

No. of Lines Resolution: 300 lines center

Video Output: 1 Vpp 75 ohms

Imaging Device: 1" single gun vidicon HS 251 Hitachi

Sensitivity: 10 fc

Shade of Grey: factory tested for optimum

Automatic Light Compensation Ratio: 10 - 10,000 fc

Signal-to-Noise Ratio: 40 db @ 100 lux

Scanning Standards: 1525 lines, 30 fps, sync internal 2:1 interlace

% Geometric Distortion: not available

Power Requirements: 12 VDC current source

Camera Lens Data: wide angle 8.5 mm f/1.5

Method of Focus: 3" minimum with dc motor

Camera Size: 6.6" x 6.1" x 15.5"

Camera Weight: 18.5 lbs in air, 25.5 lb in water

Camera Depth Limit: 1,500 fsw

Camera Cost: \$4,000 with remote focus

Control Unit, Monitor and Recorder (JVC HR 41000)

Model No.: COB-1

Model Size: 19.5" x 22.5" x 14.5"

Resolution (# Lines for Recorder): not available

Describe Environmental Protection: hermetically sealed, O-ring front, water resistant, high impact

Housing Material: corrugated sheet metal, welded

Power Requirements: 110/220 VAC 60 Hz, 14 VDC, 300 W including camera and light.

Video Response: 1 Vpp 75 ohms

Controls Provided: power on/off, camera on/off, record-playback, light intensity, camera color, volume (mon.), power (mon.), picture (mon.), bright (mon.), PAL-SECAM, degauss, ground fault, listen/talk, diver volume, observer volume, operator volume, observer headset, operator headset, speaker volume, external speaker, diver phone.

Describe Communication System: separate diver umbilical, operator and observer headsets, external speaker.

Describe Video Recorder Capabilities: not available

Describe Features to Reduce or Simplify Maintenance: 19" rack mounted, complete schematics.

Cost: \$5,500

Monitor: 8", built-in

Light

Model No.: included in camera housing, Sylvania 1999

Type Element Ised: incandescent 3400°K

Light Dimensions: mounted in camera housing

Watts: intensity variable

Candlepower: 40 cp

Power Requirements: 30 VDC, 1 amp

Cost: included with camera unit

Umbilical

Type: (1) 2 black Belden 9265; (2) polyurethane, heavy jacket (heavy duty)

Length: 250'

Features: 6 pin connectors

Cost: 52¢/ft reg.; \$2.60/ft heavy duty

System Cost

\$9,989

\$500 diver communications

\$1,200 12 VDC option

Lease

\$1,500 + \$100 freight = \$1,600

REBIKOFF

TV Camera

Model No.: DR632

No. of Lines Resolution: 250 lines @ center

Video Output: 1 Vpp 75 ohms

Imaging Device: 1" type S4089 vidicon tube

Sensitivity: 10 fc @ f/2

Shade of Grey: 10

Automatic Light Compensation Ratio: 10 - 10,000 fc for 10 shades of grey

Signal-to-Noise Ratio: 40 db

Scanning Standards: 525 lines, 30 fps; RS-170 internal sync

% Geometric Distortion: 3% in-water with corrective lens

Power Requirements: 12 VDC 7.5 W or 120 VAC

Camera Lens Data: 6.5 mm, f/1.8, diagonal angle 105° in-water

Method of Focus: none; always in-focus with Rebikoff Ivanoff full corrective lens

Camera Size: 16" x 6" diameter

Camera Weight: 27 lbs in-air, 33 lbs in water

Camera Depth Limit: 3,300 fsw

Camera Cost: \$14,933 less 15%

Control Unit, Monitor and Recorder (Monitor and Recorder Not Available)

Model No.: DR992 isolation transformer, light control for 500 W light (specifications for DR 991)

Model Size: not available

Resolution (# Lines for Recorder): not available

Describe Environmental Protection: not available

Housing Material: aluminum

Power Requirements: 115 V, 60 Hz, 1 kW

Video Response: 1 Vpp 75 ohms from umbilical

Controls Provided: on/off controls, on lamp, dimmer controls

Describe Communication System: not available

Describe Video Recorder Capabilities: not available

Describe Features to Reduce or Simplify Maintenance: list of preventative measures

Cost: \$998

Monitor: not available

Light

Model No.: (1) DR925, 250 W; (2) DR926, 500 W

Type Element Used: EHT/FTS

Light Dimensions: 8", 5.5" x 8" diameter

Watts: 250/150 W

Candlepower: 4700 lumens

Power Requirements: 115 VAC

Cost: \$925 less 15%

Umbilical

Type: 3 RG-58 coax's S6003

Length: 168' (50 m) (up to 200 m)

Features: uses RebiKoff connectors

Cost: \$833

System Cost

\$15,035

Lease

\$2,936, 30 days including freight

SUB-SEA

TV Camera

Model No.: CM-40

Number of Lines Resolution: 280 minimum @ center

Video Output: 1 Vpp 75 ohms

Imaging Device: 1" tri-electrode, single gun vidicon

Sensitivity: 10 fc

Shade of Grey: 10 per EIA RS-170

Automatic Light Compensation Ratio: 10 - 10,000 fc

Signal-to-Noise Ratio: 40 db @ 10 fc

Scanning Standards: NTSC, internal sync

% Geometric Distortion: $\pm 2\%$

Power Requirements: 12.5 amp constant current 12 W maximum

Camera lens Data: 12.5 mm, f/1.5, 65° diagonal view angle, color corrected.

Method of Focus: motor adjustment 2" to infinity

Camera Size: 14" x 6.37" diameter

Camera Weight: 24 lbs in air - 4.5 lbs in water

Camera Depth Limit: 1,000 fsw

Camera Cost: \$4,600

Control Unit, Monitor and Recorder (Recorder Not Available)

Model No.: Sea Bee II

Model Size: not available

Resolution (# Lines for Recorder): not available

Describe Environmental Protection: rugged, gasket lined, sheet metal

Housing Material: aluminum weather resistant, splash proof transit case.

Power Requirements: 115 VAC, 5 amp, 60 Hz

Video Response: 1 Vpp 75 ohms

Controls Provided: AC power on, lamp intensity, camera power, limit overload, contrast, hue, color, brightness, color balance - red, color balance - blue, focus, display data entry, data entry, depth display on, time display on, time run, time reset, VTR function switch, Mon-Rec-Plbk, VTR input, off, diver, diver/tender, tender, push-to-talk, audio power on, headset balance, speaker volume.

Describe Communication System: audio 3 party; operator, diver, diver tender.

Describe Video Recorder Capabilities: not available

Describe Features to Reduce or Simplify Maintenance: 24-hr representative service complete disassembly/assembly documentation.

Cost: \$7,750 (data entry \$1,200)

Monitor: 9" high resolution built-in

Light

Model No.: MK XIII

Type Element Used: tungsten halogen

Light Dimensions: 4" x 5" x 6"

Watts: 250 W

Candlepower: not available

Power Requirements: 115 VAC, 2.5 amps, 60 Hz

Cost: \$625

Umbilical

Type: C-9SU with voice, Black on wooden spool, single $\frac{1}{2}$ " diameter multi-conducted.

Length: 100 m

Features: outer jacket .040" polyurethane abrasion resistant, 8" bend radius.

Cost: \$1,000

System Cost

\$12,500

Lease

\$3,185, 30 days including freight

GLOSSARY

ALC	Automatic Light Compensation
amp	Ampere
comm	Communication
cp	Candlepower
CRT	Cathode Ray Tube (picture screen)
db	Decibels
dc	Direct current
EIA	Electronic Industries Association
f	Focal length
f/	f-number - The ratio of the focal length to the lens aperture diameter
fc	Foot-candle
FM	Frequency Modulation
fps	Frames per second
fsw	Feet seawater
ft	Foot (length)
GFI	Ground Fault Interrupter
hot	Light which causes incorrect color rendition and bright spots on the CRT
Hz	Hertz (cycles per second)
ISE Gulf Inc.	International Submarine Engineering Gulf Inc
JVC	Video Cassette Recorder MFG
°K	Tempertaure in degrees Kelvin
kW	Kilowatt
lbs	Pounds
lux	1/10 foot-candle
m	Meters
mm	Millimeter
NEDU	Navy Experimental Diving Unit
n.o.	Normally open
NTSC	National Television Standards Code
ohms	Electrical resistance
TV	Television

GLOSSARY
(Continued)

VAC	Volts, Alternating Current
VCR	Video Cassette Recorder
VDC	Volts, Direct Current
Vpp	Volts, peak to peak
W	Watt
washout	Overexposure
@	At
'	Foot
"	Inch
#	Number
%	Percent



DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
PANAMA CITY, FLORIDA 32407

IN REPLY REFER TO:

NAVY EXPERIMENTAL DIVING UNIT

REPORT NO. 1-81

EVALUATION OF COLOR UNDERWATER CCTV
AND TOPSIDE EQUIPMENT

MR. JERRY D. PELTON

JANUARY 1982

ADDENDUM 1

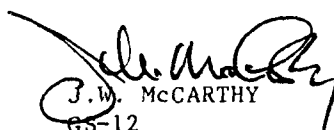
Approved for public release; distribution unlimited


Submitted by:

Reviewed by:

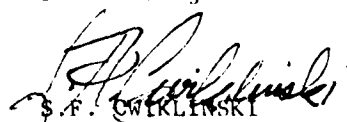
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ADDENDUM 1

Introduction

The purpose of this addendum is to include the HYDRO PRODUCTS Color Underwater Closed-Circuit Television System with NEDU Report No. 1-81, Evaluation of Color Underwater T.V. and Topside Equipment. This unit was not available at the time of the original testing. Although not tested under identical conditions to the other units, it was used during a typical fleet operation and therefore was representative of the intended environment. The same twelve factors were evaluated. Numeric ratings are adjusted for the addition of a sixth unit and are included at the end of each factor discussed. Table 4A, Comparative Ratings Summary Chart, is adjusted accordingly to reflect the new numeric ratings and includes an overall rating for the best average rating. The testing included gathering both objective and subjective data which were used in evaluating the systems.

System Descriptions

Table 1
List of Manufacturers

<u>Manufacturer</u>	<u>Model No.</u>
HYDRO PRODUCTS 11777 Sorrento Valley Road San Diego, CA 92121	Hydro Color TC-181

HYDRO PRODUCTS Hydro Color T.V. System TC-181

The HYDRO PRODUCTS' Hydro Color T.V. System is shipped in four (4) containers constructed of plywood with aluminum angle framing on all corners. The contents of each container is covered in the Portability Section of this report.

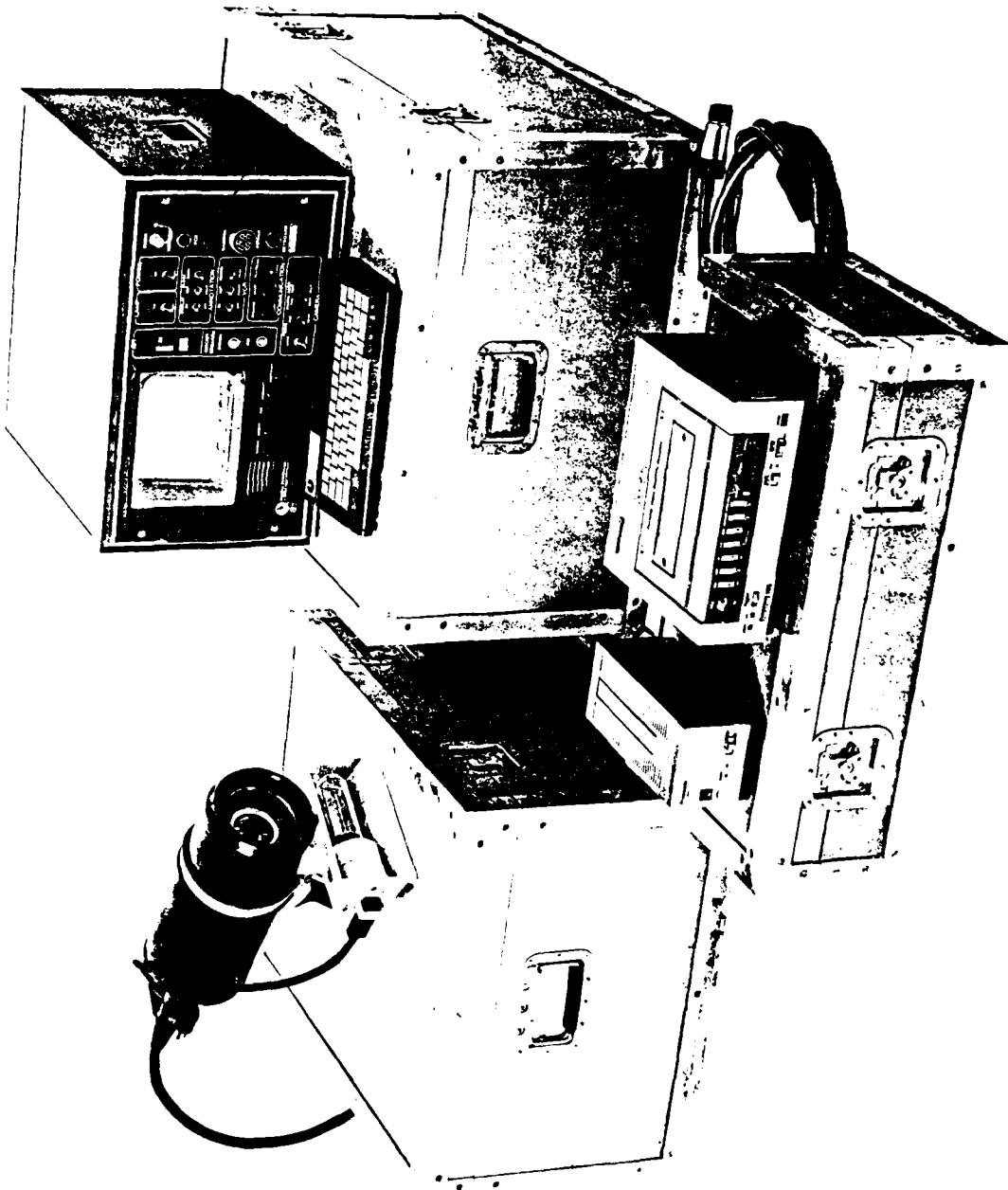
The Hydro Color system includes: diver communication (not tested), seven inch diagonal color monitor, selectable automatic and/or manual camera and power controls (the automatic section was not tested), on-screen alphanumeric data including elapsed time, focus distance and keyboard entry for additional data.

A unique feature of the Hydro Color camera is that it can be interfaced with the UDATS control unit and umbilical through an auxillary unit (retrofit kit).

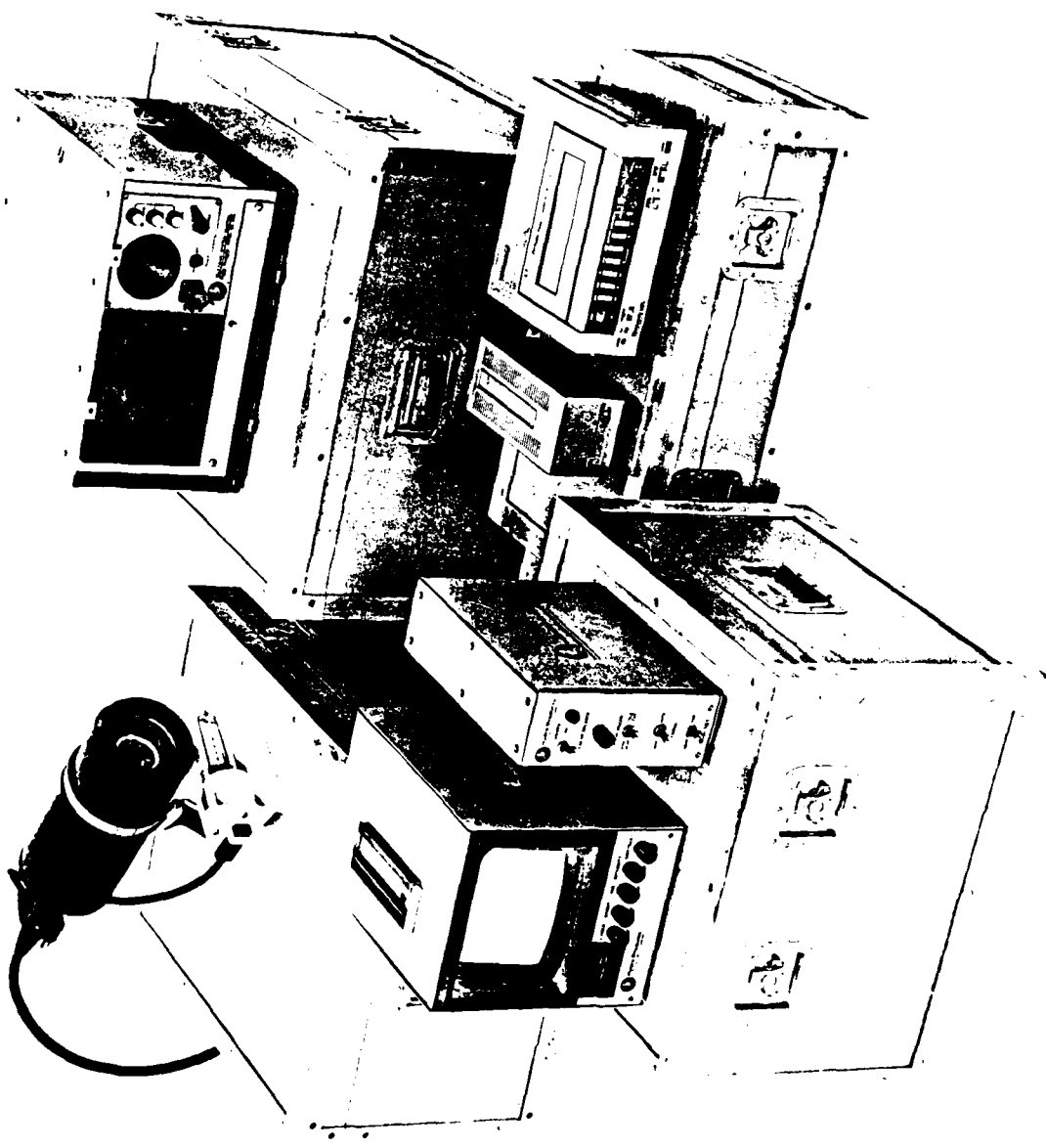
Target Descriptions

1. Daylight - low turbidity - This test was performed during the SEALAB I Recovery Operation in the Gulf of Mexico off Panama City Beach, FL, in clear very low turbidity conditions.

2. Daylight - high turbidity - This test was performed during the SEALAB I Recovery Operation during the test and evaluation of air lift removal methods for sand from around ballast on the SEALAB skids.



HYDRO PRODUCTS HYDRO COLOR TV SYSTEM TC-181
COMPONENTS WITH SHIPPING CONTAINERS



HYDRO PRODUCTS HYDRO COLOR TV SYSTEM TC-181
WITH RETROFIT KIT FOR UDATS CONTROL UNIT AND UMBILICAL

3. Night - low turbidity - NEDU 15 foot deep test pool using color test chart.

4. Night - high turbidity - Inside SEALAB I.

The test targets were:

1. SEALAB I hull (before cleaning).
2. Pool target.
3. SEALAB I hatches.
4. Air lift (suction and discharge).
5. Color test chart.

RESULTS AND DISCUSSIONS

Test results were correlated and analyzed in relation to the evaluation of the Color Underwater T.V. Systems in NEDU Report No. 1-81, with the following results:

Ability to Perform Intended Function

The primary function of all of the tested units is to provide simultaneous television monitoring with both video and audio recording capabilities for in-water inspections of submerged hulls and waterfront facilities.

The HYDRO PRODUCTS system had a good quality control console with an optional data entry keyboard, which was very useful for entering different jobs, tasks, etc. The light on the Hydro Color system is controlled by an on/off toggle switch with a lamp power-on indicator, with no means however, to vary lamp intensity. The Hydro Color system features a remote color balance switch with 16 positions, focus near/far, and zoom/macro focus control. The focus controls worked very well and added to the overall ability of the system to perform the intended function of providing good underwater color television coverage.

Ratings between the six units with respect to intended functional performance are listed below. The rating scale is from 1 to 6 with number 1 being the best unit in a specific area of evaluation and number 6 being the worst.

<u>Unit</u>	<u>Rating</u>
AQUA-AIR	5
ISE GULF	6
KINERGETICS	4
REBIKOFF	3
SUB-SEA	1
HYDRO PRODUCTS	2

Table 2A
Comparative Cost Breakdown

Manufacturer	TV Camera	Control Unit & Monitor	Light	Umbilical	System Cost	Lease (30 Days Including Freight)
HYDRO PROD.	6,200	6,800	995.	1,825	\$22,045.	2,700

Numeric ratings for cost were not used in the original report but have now been included. The best rating is for the lowest "system cost." As price quotations are subject to change, comparative costs will vary widely in the future. Also, buyers should bear in mind that not all systems are comparably equipped and this has a lot to do with the system prices.

<u>Unit</u>	<u>Rating</u>
AQUA-AIR	3
ISE GULF	1
KINERGETICS	2
REBIKOFF	5
SUB-SEA	4
HYDRO PRODUCTS	6

Portability

In this category, the size and weight of the system in its packaged condition are considered for handling by two people.

The system is shipped in four containers constructed of plywood with aluminum angle framing on all corners (see photos). The Surface Control Unit (SCU) container measured 28"x25"x15", shipping weight 130 pounds. The camera, light and bandmask container measured 30"x23"x15", shipping weight 90 pounds. The VCR container measured 24"x21"x14", shipping weight 82 pounds. The umbilical container measured 27"x21"x27", shipping weight 145 pounds.

The comparative portability ratings of the six tested T.V. systems are as follows:

<u>Unit</u>	<u>Rating</u>
AQUA-AIR	1
ISE GULF	6
KINERGETICS	2
REBIKOFF	3
SUB-SEA	5
HYDRO PRODUCTS	4

Support Required

This evaluative criterion refers to the ease of system setup and to whether an umbilical tender, in-water, is recommended.

The HYDRO PRODUCTS system setup can be accomplished in 10-12 minutes. Only one person is needed with the exception of breaking out the umbilical when two people are needed due to the weight and bulk of the cable. Once the system is set up and operating, one person can operate the system with ease. An in-water tender is recommended to handle the umbilical if the diver with the camera needs to stretch out long lengths of umbilical and still be able to swim freely.

The ratings of the six units per support required are shown below:

<u>Unit</u>	<u>Rating</u>
AQUA-AIR	6
ISE GULF	5
KINERGETICS	2
REBIKOFF	1
SUB-SEA	3
HYDRO PRODUCTS	4

Problem Areas

This evaluation pertains to the occurrence of any failures during testing and covers only a short period of time.

The HYDRO PRODUCTS system's only negative aspects were the size and weight of the umbilical, and that the lamp intensity cannot be controlled. The lack of a lamp intensity control causes problems in high turbidity situations due to backscatter.

The problem area ratings of the six tested systems are as follows:

<u>Unit</u>	<u>Rating</u>
AQUA-AIR	2
ISE GULF	5
KINERGETICS	1
REBIKOFF	6
SUB-SEA	4
HYDRO PRODUCTS	3

Operational Aspects

Information pertaining to this criterion was obtained through diver interviews and the human factors assessment forms.

HYDRO PRODUCTS - The controls grouping, labeling, and ease of operation were very good. Connections on the surface control unit were easy to mate up and are well marked.

The operational aspects ratings among the six tested systems are shown below:

<u>Unit</u>	<u>Rating</u>
AQUA-AIR	4
ISE GULF	5
KINERGETICS	3
REBIKOFF	6
SUB-SEA	2
HYDRO PRODUCTS	1

Handling Aspects

Information through diver interviews and the human factors assessment forms provided the following points concerning in-water camera handling:

The HYDRO PRODUCTS camera is easy to handle, the weight is 14.5 pounds in air and 2.5 pounds negative in water. The camera and umbilical can be handled by one free swimming diver with ease for moderate distances and times of 40 to 50 feet 30 to 40 minutes. Beyond these parameters an in-water tender is recommended.

The handling aspect ratings are shown below:

<u>Unit</u>	<u>Rating</u>
AQUA-AIR	5
ISE GULF	6
KINERGETICS	1
REBIKOFF	4
SUB-SEA	3
HYDRO PRODUCTS	2

Lens Features and Focal Length

Features discussed are the limiting focus distances, lens data and remote focus ability.

HYDRO PRODUCTS - The camera uses a 11.5mm to 70mm (6:1) zoom/macro focus f 1.8 zoom focus: 4.0 feet to infinity. Macro focus (wide angle) 4 inches (1 inch in front of viewport) to infinity and has remote manual (automatic option available, not tested) focus control.

The HYDRO PRODUCTS focus capability was as good or slightly better than the original cameras that were tested and found satisfactory. The macro focus features allowed for very good depth-of-field or close-up inspection of small objects and areas.

Camera Ability to Enter Small Areas

Diver interviews and human factors assessment forms led to the following conclusions concerning the cameras ability to enter small areas (24-inch diameter openings):

The HYDRO PRODUCTS camera will fit into openings of 24" diameter with some difficulty because of the size of the camera and light assembly.

Ratings among the six tested units per ability to enter into confined spaces are given below:

<u>Unit</u>	<u>Rating</u>
AQUA-AIR	2
ISE GULF	5
KINERGETICS	1
REBIKOFF	6
SUB-SEA	4
HYDRO PRODUCTS	3

Illumination Characteristics

This criterion includes lamp power, lamp placement, camera sensitivity and resistance to washout.

The Hydro Color system has a 300 watt quartz iodide lamp with reflector mounted below the camera and drawing 120 volts A.C. constant 2.5 amp current from the control console for correct color temperature independent of cable length. The light reflector dimensions are 8.8" wide x 9.56 long. Automatic light compensation of the camera is 5-10,000 foot candles. Only minor hot spots occurred on bright objects up close, and most of these were not detrimental to the overall picture quality.

Ratings among the six tested units with regard to illumination characteristics are shown below:

<u>Unit</u>	<u>Rating</u>
AQUA-AIR	6
ISE GULF	5
KINERGETICS	4
REBIKOFF	3
SUB-SEA	1
HYDRO PRODUCTS	2

Technical Documentation

Specification on each of the six units are provided in Appendix A. Remarks on clarity and appropriateness of the technical literature are included below:

HYDRO PRODUCTS - Hydro Color system arrived at the test site with a very preliminary manual that was incomplete. A manufacturer's representative was on hand to go through the setup/operation procedures with the test team during the first two days of the test. The manufacturer stated that future units will come with a set of complete manuals for operating and troubleshooting the entire system.

Ratings among the five tested systems for existing technical documentation are given below:

<u>Unit</u>	<u>Rating</u>
AQUA-AIR	6
ISE GULF	3
KINERGETICS	2
REBIKOFF	5
SUB-SEA	1
HYDRO PRODUCTS	4

Safety Features

Recognizing that the approved T.V. systems will be used as maintenance/salvage tools and, for that reason, will often be used under less than ideal conditions, i.e. ship of opportunity, adverse weather, etc., this system was evaluated, as were the original 5 units tested, for a specific set of safety parameters. Of concern is both diver and surface operator safety. Safety features evaluated include:

1. System ruggedness
2. Stability
3. Packaging
4. Cable durability
5. Power requirements
6. Electrical isolation/GFI (Ground Fault Interrupter)

Systems were down rated if they required multiple cable connections between components and further down rated if it was possible to make incorrect connections due to poor or inadequate labels or connector similarities. A tabulation of these parameters is given in Table 3 of the original report and at the end of this summary for the Hydro Color system.

Hydro Color

This system features good rugged packaging and during the test demonstrated its ability to perform under adverse conditions. The operator is protected by a GFI system. To protect the diver, only low voltage DC power reaches the camera. The 300 watt light operates on 120 volts AC power that is supplied by a constant current AC isolation transformer. Also there are two threshold circuit breakers, one for the T.V. system and one for the video cassette recorder.

Labeling on the control unit is excellent. Hookup is straightforward with no chance of making wrong connections either on the control unit or the camera. The cable was awkward to handle (as shipped) and did create problems until it could be made up properly. More care needs to be put on packaging of the umbilical cable. Handling this cable on small deck space at sea in the condition it arrived at the test site could be hazardous.

The safety features ratings are shown below.

<u>Unit</u>	<u>Rating</u>
AQUA-AIR	2
ISE GULF	5
KINERGETICS	1
REBIKOFF	6
SUB-SEA	4
HYDRO PRODUCTS	3

Test Team Overall Preference

The last evaluative factor was the test team's subjective ranking of the underwater closed-circuit TV systems according to the team's personal preference with all factors considered. A mutually agreed upon ranking is given below.

<u>Unit</u>	<u>Rating</u>
AQUA-AIR	5
ISE GULF	6
KINERGETICS	2
REBIKOFF	4
SUB-SEA	1
HYDRO PRODUCTS	3

Conclusions

User preference was considered the most significant factor in the test and evaluation of these closed-circuit T.V. systems. Selection of a system for a specific mission is best done by review of the relative grades given on Table 4A for the factors of concern to that mission.

Table 3A

SAFETY ITEM	MFGR.	HYDRO PRODUCTS
Electrical Protection		
	<u>Topside</u>	GFI
	Diver	Isolation Transformer
Labeling		Excellent
Power Requirements		
	<u>Camera</u>	12 Volts D.C. Constant Circuit
	<u>Light</u>	120 Volts A.C. Constant Current 2.5 AMPS
	Control/VCR/ Monitor	120 Volts A.C. + 10%, 60 Hz, 5 AMPS (includes lamp power)
	<u>Strain Relief</u>	Yes, Internal
Umbilical		
	Rugged	Yes, Abrasion Resistance Polyurethane Jacket
Connection Wires Between Components		Acceptable, Only Two Short Cables Other Than Camera Umbilical
Packaging/Set Up		Umbilical Packing Poor, Set Up Good. Two Containers Over 100 Lbs. Each

	Ability to Perform Intended Function	System Cost (\$)	Portability	Support Required	Problem Areas	Operational Aspects	Handling Aspects	Lens Features and Focal Length	Camera's Ability to Enter Small Areas	Illumination Characteristics	Technical Documentation	Safety Features	Test Team Overall Preference	Numeric Rating Point Average	Overall Numeric Rating
AQUA-AIR	5	3	1	6	2	4	5	17-102 mm	2	6	6	2	5	3.92	4
ISE GULF	6	1	6	5	5	5	4	14-56 mm	5	5	3	5	6	4.83	6
KINERGETICS	4	2	2	2	1	3	1	8.5 mm	1	4	2	1	2	2.17	1
REBIKOFF	3	5	3	1	6	6	4	11.6.5 mm	6	2	5	6	4	4.33	5
SUB-SEA	1	4	5	3	4	2	1	12.5 mm	4	1	1	4	1	2.75	2
HYDRO PRODUCTS	2	6	4	4	2	1	2	11.5-70 mm	3	2	4	3	3	3.0	3

Table 4A. COMPARATIVE RATINGS SUMMARY CHART

References

1. NEDU Test Plan 80-4 "Color Underwater T.V. and Topside Equipment," dated May 1980.
2. NEDU Report 1-81 "Evaluation of Color Underwater T.V. and Topside Equipment," dated January 1981.
3. NEDU Test Plan 81-24 "Color Underwater T.V. and Topside Equipment," dated May 1981.
4. Manufacturers' Tech Manual and Written Instructions by Factory Representative.

APPENDIX A

HYDRO PRODUCTS COLOR T.V. SYSTEM

T.V. Camera

Model No.:	TC-181
No. of Lines Resolution:	260 (Luminance)
Video Output:	1 V P-P Nominal, Sync Negative
Imaging Device:	Color Stripe Vidicon, 2/3"
Sensitivity:	5 Foot Candles Equivalent Scene Illumination
Shade of Grey:	9 Minimum
Automatic Light Compensation Ratio:	5-10,000 FC
Signal-to-Noise Ratio:	43dB with 140 Ft Candles Equivalent Scene Illum.
Scanning Standards:	525 Lines, 60 Fields, 30 Frames/Sec (NTSC Color)
% Geometric Distortion:	2% Maximum
Power Requirements:	12 volts from constant current source in control unit
Camera Lens Data:	F 1.8 Power Zoom & Macro Focus, 11.5 - 70mm
Method of Focus:	Motor driven - remote control
Camera Size:	L: 13 3/4" Dia: 5 7/8"
Camera Weight:	14 lb. in air, 2.5 lb. in water
Camera Depth Limit:	2000 ft.
Camera Cost:	\$6,200 00

Control Unit, Monitor and Recorder

Model No:	SC-181
Model Size:	HT: 12 5/16" W: 21 13/16" Depth: 21" Wt: 60 lbs + recorder 19 lbs.

Control Unit, Monitor and Recorder (cont'd)

Resolution (# Lines for Recorder):	240 LPPH
Describe Environmental Protection:	Splash-proof rugged aluminum enclosure
Housing Material:	Aluminum alloy, painted
Power Requirements:	120 VAC + 10%, 60 Hz, 5 Amps (includes light power)
Video Response:	To more than 4 MHZ, standard NTSC color roll-off
Controls Provided:	See Specs and brochure
Describe Communication System:	See Specs and brochure
Describe Video Recorder Capabilities:	2/4/6 hour VHS format, remote controls
Describe Features to Reduce or Simplify Maintenance:	Long life components Conservative design, plug-in cards
Cost:	\$6,800.00
Monitor:	7 inch high quality color monitor

Remote Color Balance

Automatic Color Balance vs. Distance for Sea Water Characteristics

Light

Model No.:	LQ-8-300
Type Element Used:	Quartz Iodide Incandescent
Light Dimensions:	8.8" W X 9.56" L
Watts:	300 W
Candle Power:	1440
Power Requirements:	120 VAC or constant 2.5 amp current from control console for correct color temperature independent of cable length
Cost:	\$995.00

Umbilical

Type:	Mdl. C-105/abrasion resistant polyurethane jacket over lightweight cable assy.
Length:	250 Ft.
Features:	Conductors for TV camera, power, focus control, video, communications, and underwater light assy.
Cost:	\$1,825.00

System Cost

\$22,045.00

Lease

\$2,700.00, for 4 weeks

DATE
ILME